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Ovarian structure and plasma steroid hormones of triploid female rainbow trout

Masaru NAKAMURA*, Yoshitaka NAGAHAMA**,
Masao IWAHASHI*** and Masao KOJIMA***

One knows that many triploid female salmonids are sterile (Benfey and Sulterlin 1984, Lincoln and Scott 1984, Solar et al. 1984). This is why triploid females have numerous advantages with respect to rearing. It is for instance possible to avoid the decline in growth that accompanies maturation and to avoid death following spawning. In the present study, we report the results obtained through histological, and microstructure observations of the ovaries of triploid female rainbow trout (Salmo gairdneri) having reached maturity age as well as through the measurements of steroid hormones in the blood of the same fish.

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Materials and method We reared for a long period of time (21-27 months) triploid fish produced through high-temperature treatment of fertilized eggs (6-10 min immersions at 26-30°C ten minutes after insemination) and used the same as specimens. We determined the final triploids by measuring the major axis of the red blood cells. We fixed the genital glands for electron microscope (observation). After embedding them in Epon resin, we prepared 1 μ ultrathin slices and made observations with optical and with electron microscopes. We measured the amounts of steroid hormones in the blood plasma by the radio immuno assay method.

Results and discussion The ovaries of the mature control diploid females of the control group contained mainly small eggs at the early yolk-forming stage in July, and large eggs at the formed yolk stage in October. In January, there were individuals with completely formed yolks on the verge of ovulation (photograph) and other individuals busy ovulating. The genital gland index (GSI) too increases suddenly as maturation progresses (0.8 - 13.8) (Fig. 1). The unripe eggs of diploids are at any time represented mainly by eggs at the yolk sac* stage

* translator's note :

not quite certain; possibly, one character is missing and the meaning would then be "yolk cell"; same for * under photograph 2.

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(photograph 2) and the GSI too is as low as 0.1 - 0.2 (Fig. 1). The ovaries of the triploids are at all times remarkably small (photograph 1), histological observations reveal thickening greater than at the peripheral kernel period and no development of oocytes is seen at all. In the thin ovary slices, one sees numerous utricles containing large numbers of immature reproductive cells (photographs 3 and 4). In the center one often saw retrograded reproductive cells (photograph 4). Therefore, the GSI is as low as 0.02 - 0.03 (Fig. 1). Electron microscope observations reveal a synaptonema structure in the nuclei of numerous reproductive cells (photograph 5) which confirms that the reproductive cells are oocytes at the stage preceding the first reduction division. This differs from the report (Lincoln and Scott 1984) that no oocytes are observed in the ovaries of triploid female rainbow trouts. Steroid hormones-producing cells and granular membrane cells were identified under electron microscope. Yet their activity was low (photograph 5).

The variations of steroid hormone volumes in the blood of the mature diploid group agreed with the so far known results for rainbow trout (Fig. 1). Estradiol -17 ß (E_2) is high at the July and October yolk formation time. In January, it was high in the individuals at the pre-ovulation stage. It was low in the individuals having ovulated, and eggs were seen to be in the abdomen (12.9 - 15.7 ng ml^{-1}). Testosterone (T) increased at the oocyte formation stage. It rose again at the maturation period (9.4 - 42.5 ng ml^{-1}). The 17 α, 20 ß-dihydroxy-4-pregnen-3-one

(17 α, 20 ß-diOHprog) which are believed to be hormones inducing egg maturation in salmonids are low at the yolk formation stage, and increased remarkably at the spawning stage (0.2 - 2.7 ng ml^{-1}).

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On the other hand, the volumes of E_2, T, 17 α, 20 ß-diOHprog were commonly low in the immature diploid group. They were 0.4 - 0.9, 0.9 - 2.4, 0.2 - 0.5 ng ml^{-1} respectively (Fig. 1).

The volumes of E_2, T, 17 α, 20 ß-diOHprog in the blood of triploids were always low. They were 0.2 - 0.6, 0.7 - 1.7, 0.2 - 0.4 ng ml^{-1} respectively. There was virtually no difference from the immature diploid group (Fig. 1).

One of the main reasons for the sterility of female triploid is the non-disjunction of the chromosomes at the synopsis stage of the first maturation division. The present study indicates the possibility of another cause, viz. a drop in the secretion of steroid hormones.

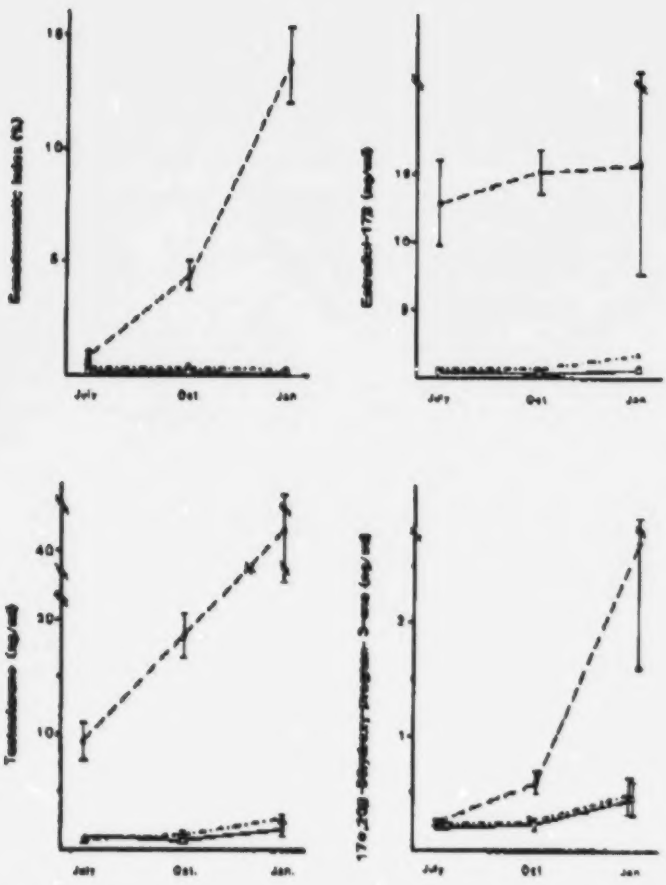

図1　三倍体と二倍体雌の生殖腺指数と血中 Estradiol-17β, Testosterone, 17α, 20β-dihydroxy-4-pregnen-3-one 量　二倍体雌（○——），二倍体成熟雌（●－－－），二倍体未成熟雌（▲－・－・－・）

Fig. 1　Gonadial index and Estradiol -17 ß, Testosterone, 17 α, 20 ß-dihydroxy-4-pregnen-3-one volumes in triploids and diploid females

diploid females (O _____)

diploid mature females (● _ _ _ _)

diploid immature females (▲ _·_·_·)

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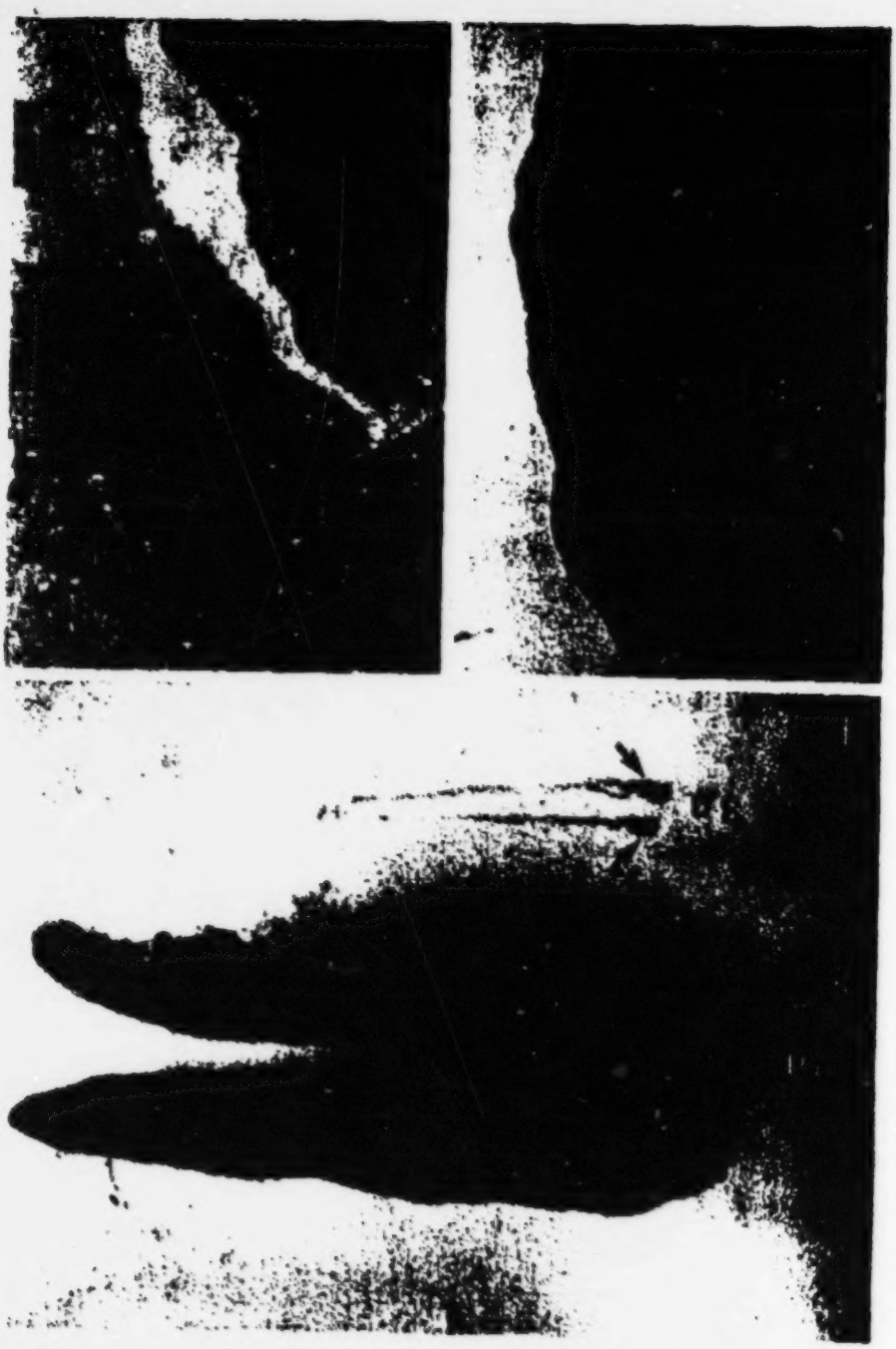
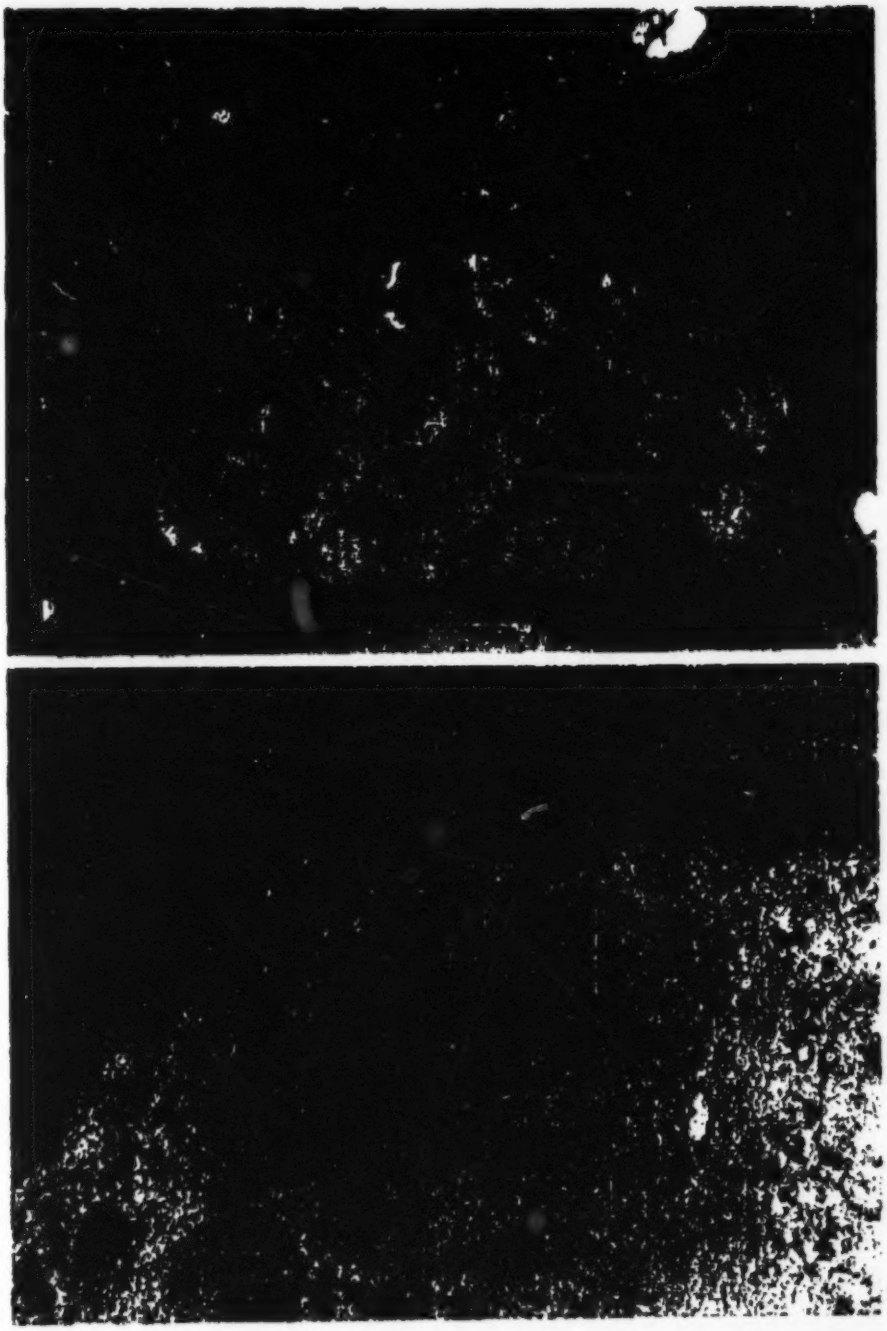


Photograph 1 Ovaries of triploids (3 n) and of diploids (2 n) in January. The ovary of triploids is remarkably small. Numerous reproductive cells are contained in the swollen part of the tip (arrow sign)

Photograph 2 Immature ovary of diploid. Oocytes at the yolk sac* stage and peripheral kernel stage are developing. x 165

Photograph 3 Ovary of triploid. One sees numerous utricles containing immature reproductive cells. x 165



Photograph 4 Utricle of triploid ovary. It contains numerous oogonia, oocytes; at the center one sees a retrograded picture of reproductive cells x 825

Photograph 5 Electron microscope image of part of the ovary utricle in triploid; there are steroid hormone producing cells (Spc) surrounding the utricle from the outside and granular membrane cells (Gc) surrounding the utricle from the inside. One sees a synaptonema structure (arrow sign) in the nucleus of the oocyte (Oc) x 4360

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